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IMPLEMENTATION OF LEARNING MANAGEMENT SYSTEMS WITH GENERATIVE ARTIFICIAL INTELLIGENCE FUNCTIONS IN THE POST-PANDEMIC ENVIRONMENT

Abstract. In recent years, the global education system has undergone a transformative shift, relying increasingly on online tools to prove its resilience in the face of various challenges, including epidemiological events. This paper seeks to introduce a Learning Management System (LMS) designed to elevate the delivery of educational content, fostering the training and development of students' knowledge in a dynamic and adaptive learning environment anchored to the connectivity and synchronization needs of smart urban living. The system proposes the integration of a language generation model equipped with Application Programming Interface (API) access. This choice not only streamlines instructor support but also facilitates the creation of courses using an adapted and coherent language. The system goes beyond traditional LMS functionalities by providing suggestions to enhance and diversify lessons. Emphasizing flexibility and adaptability, the proposed LMS caters to various training levels, being able to accommodate the needs of learners across different domains. To identify the appropriate solution, a comparative analysis was conducted, evaluating various platforms based on functionality, intuitive presentation, and customization options. The selected system emerged as the most favorable, offering a robust framework for the development and delivery of educational content. To demonstrate the system's effectiveness, a curriculum was crafted for a specialized field of study - Artificial Intelligence (AI), with a specific focus on the practical application of Machine Learning algorithms. This curriculum incorporates theoretical and practical application components, complemented by a suite of assessment tools and assignments tailored to the proposed subject. The lessons within this curriculum were constructed by drawing insights from various bibliographical sources. What sets this system up-to-date is its integration of generative AI features directly into the LMS, enriching the teaching-learning-evaluating experience.

Keywords: online learning; Learning Management System; Generative Artificial Intelligence; COVID-19.

1. INTRODUCTION

The problem statement. We are in a context full of uncertainties generated by the critical and disruptive events we have experienced in recent years, the most significant being the global epidemic caused by the COVID-19 virus. This crisis not only revealed the vulnerabilities of society but also the rapid contagion effect between various systems. This health crisis has left its mark on all aspects of life. Measures to restrict the mobility of the population through a total or partial lockdown were essential for limiting virus transmission as much as possible [1], leading to the maintenance of only essential activities and especially affecting educational processes. In May 2023, the COVID-19 epidemic, which began as a pandemic at the start of 2020, was declared to no longer be a public health emergency of international concern [2] because of a significant reduction in infection cases.

The pandemic has demonstrated that educational systems, both public and private, must possess the resilience necessary to remain viable despite adversity. Finding alternative solutions to conventional education was essential for the educational process to be as little affected as possible, as educational institutions were physically closed during lockdown periods. Thus, the attention in these years has shifted more than ever to the direction of online education, even if

the education systems in some countries, especially the mainstream ones, were still pioneers in this regard.

The transition to the online learning system was achieved naturally, considering the prerequisites of connectivity and the high speed of the Internet. This allowed the use of digital platforms, resources, and communication through audio-video conferences in the teaching-learning-evaluation process. Both teachers and students had to adapt to this radical change. The teachers had to develop their computer skills, create new ways of teaching, and meet the new requirements of the virtual environment. Instead, students had to take on more responsibility for independent learning. Despite the challenge of rapidly transitioning to online learning, certain beneficial practices have been identified that can become an integral part of education [3].

Analysis of recent studies and publications. In the evolution of education systems, the concept of e-learning, which includes online interaction tools, breaks traditional barriers and mobility limitations, offering flexibility [4], and promoting digital citizenship. This modality involves synchronous communication between the instructor and students. Similar to traditional classroom education, the use of video conferences and real-time discussion sessions allows feedback and interaction. It also involves the asynchronous mode, which allows access to materials that can be studied independently, without a predetermined schedule, and that can be accessed anytime by students to consolidate their knowledge. This interaction type involves minimal communication with the instructor. The two methods of interaction are not mutually exclusive. The lessons can be built in a mixed way, and combining these methods can constitute a more complete teaching–learning method [5].

During the independent learning process, learners may find it challenging to manage their study materials from which to start in a topic-discovery process, both regarding the theoretical and practical approaches. The abundance of information can be overwhelming, making it difficult to select relevant and credible materials. Students may have difficulties synthesizing information, managing their time efficiently, and finding correlations between theoretical notions and their practical application. The emergence of Learning Management Systems (LMS) has represented a significant revolution in the way distance educational processes can be conducted [6]. These platforms allow the development of interactive courses by specialists in the field of education. Courses can be structured in the form of modules and lessons adapted to various levels of users, from beginners to advanced. Also, these facilitate learning and easy understanding of essential concepts by presenting them in a structured and logical manner. These systems can successfully combine both synchronous and asynchronous activities [7].

LMSs are modern tools that can support the educational process and improve academic results. This type of system proved to be of real help during the pandemic for education systems [8], being considered in various research as a productive learning method that managed to successfully engage students even in times of crisis [9]. In addition to the simple management of courses, resources, and data flow administration, the innovative features of such systems are remarkable. For example, gamification elements can create a competitive atmosphere through a reward system, points, and rankings. Discussion forums are favorable for the exchange of ideas, connecting students with each other, and facilitating the connection between students and tutors. Integration with other educational applications and modern technological systems enhances the learning experience, including the incorporation of video-conferencing platforms (example: Zoom, Google Meet, Microsoft Teams, etc.), and integration with generative features based on artificial intelligence (AI) and large language model APIs (example: OpenAI GPT-3.5/ 4, Google PaLM 2 and Gemini, Meta LLaMA, etc.)

The incorporation of generative AI in LMS-type platforms is a current direction [10] that can yield beneficial results for both instructors and learners. Compared to traditional AI models, generative AI brings a series of significant changes in terms of democratizing access, allowing

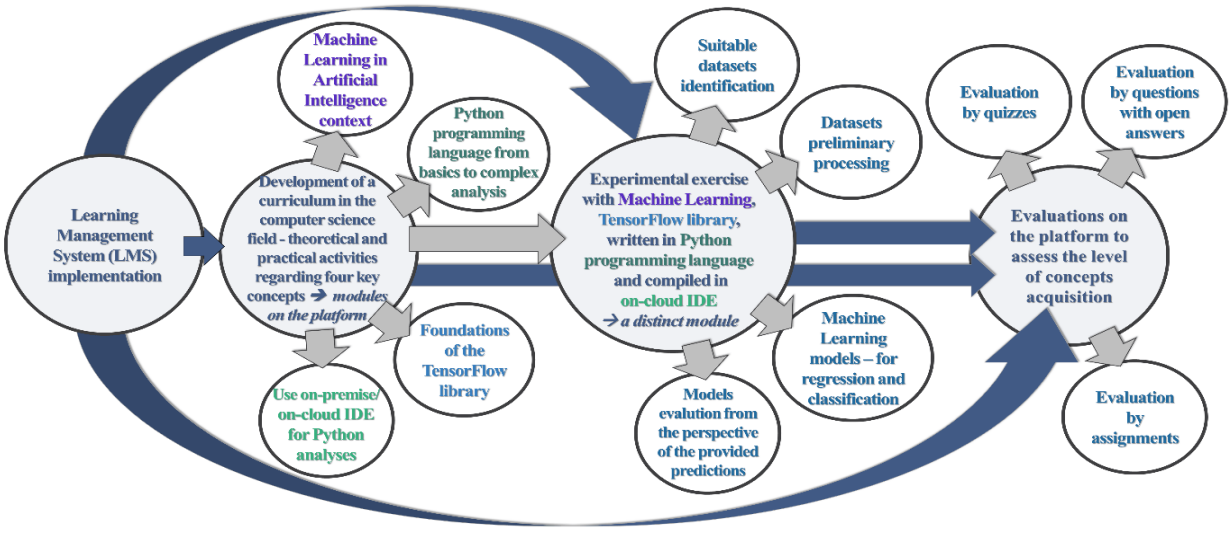
users to interact in a natural language, without the need for advanced technical knowledge. It generates content from multiple domains based on pre-trained models. It can adapt in real-time with new training data entered as input, generating content that is better focused on the subject, and customizing the content according to individual needs. It provides inspiration and support in creative processes. This tool can be used to create educational content, generate test questions, recommend additional topics, and provide automated feedback for exercises. However, AI must be used with caution for educational purposes, taking into account the ethical implications [11]; it is also essential the use of critical thinking to appreciate the quality of automatically generated information.

The research goal. The main purpose of this paper is to present the benefits of implementing a modern LMS for delivering educational content with the scope of training, developing, and managing students' knowledge. In addition to the classic functionalities, the focus is primarily on the possibility of integrating generative AI functionalities. The selection of an LMS will be performed through comparative analysis. The platform will be tested by creating and uploading a demonstration computer science course, developed based on a selective bibliography, and using generative AI features. The paper is organized into four main sections. The second chapter presents the approach from a methodological perspective – the research framework and the modeling of the IT task. In the third chapter, the main research findings are presented. This includes a comparative study of various LMSs compatible with generative AI, highlighting their advantages and limitations, selecting the most suitable LMS, exploring available generative AI functionalities, and detailing the implementation of the proposed system. In the final section, the conclusions are outlined.

2. METHODOLOGICAL APPROACH

2.1. Research framework

From the methodological standpoint, this study seeks to implement a LMS used in teaching, learning, and evaluation activities to facilitate the acquisition of knowledge for the final beneficiaries – the students. The research workflow is depicted in Figure 1. The platform is proposed to be highly attractive and intuitive to ensure that students can easily comprehend the lessons, regardless of their technical skill level.



(Source: author's own representation)

Figure 1. Research workflow

The platform is designed for both independent use and for interaction with the instructor. The instructor can assess micro-assignments asynchronously and provide comments, advice, and feedback to students. In addition, synchronous communication can be achieved through the integration of video-conferencing technical capabilities.

The testing of this platform is accomplished by integrating a demonstration computer science course designed to introduce students to a rapidly advancing field, namely a branch of artificial intelligence - Machine learning (ML). Thus, a curriculum is developed to present theoretical and practical perspectives on supervised and unsupervised learning algorithms. The strengths and weaknesses of each type are highlighted. Various representative algorithms are studied and used for regression and classification problems - in the case of supervised learning, and clustering algorithms - in the case of unsupervised learning. Information technology tools useful for computerized analysis, such as the Python programming language and associated libraries for data understanding and preparation, are introduced in order to develop ML tasks. In particular, the TensorFlow library is described in detail being a relevant and recently developed library that fits such analyses. Many other libraries, useful in the preprocessing and model evaluation stages, are introduced.

Multiple LMS platforms are compared in terms of documentation, installation, configuration, and customization. Solutions that enable attractive theoretical and practical presentations of lessons and native integration with generative AI tools are especially considered. A comparative analysis was also conducted to highlight multiple plugins based on generative AI compatible with the chosen LMS. This section highlights the functionalities, integrated AI models, and the possibility of fine-tuning the models.

A conceptual understanding of the necessary software modules is achieved through modeling. This involves creating use-case schemes to define the functionalities required within the LMS platform and how the main actors – admin, instructor, and learner – interact with the system. The platform offers courses, lessons, practical examples, and self-assessment tests. An Integrated Development Environments (IDEs) platform, either on-premise or on-cloud, is used to execute practical applications within the lessons, ranging from basic Python scripts to ML analyses with the TensorFlow library. The ML process involves the classic steps of exploratory analysis, data cleaning, splitting into training and test sets, and model application. At the end of each lesson, mastery of concepts is evaluated using evaluative questionnaires, open-ended questions, and assignments. Summative tests are applied at the end of each module.

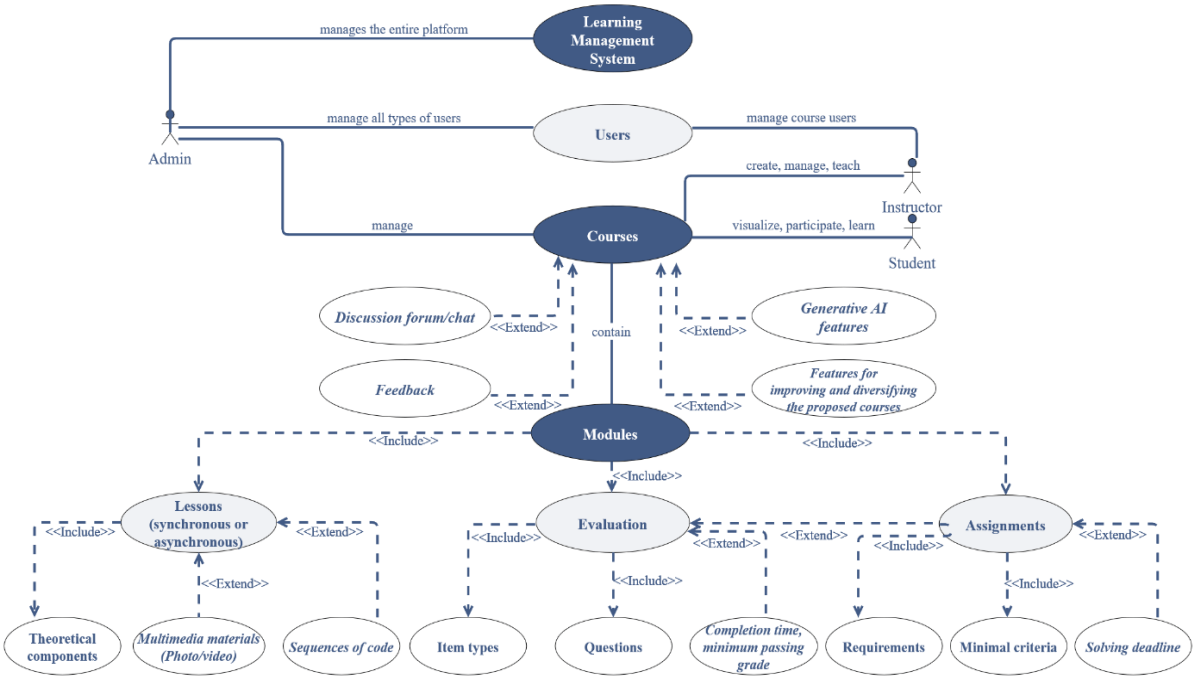
2.2. Modeling LMS platform requirements

This study seeks to install, configure, and customize an LMS platform that focuses on three types of actors: Administrator, Instructor, and Learner. The Administrator („Admin”) is responsible for overseeing the entire platform, managing user types, and handling various technical aspects. The "Instructor" is responsible for managing their own courses, overseeing users participating in their courses, and approving user accounts. The instructor creates new courses and manages existing ones, monitoring forum discussions, providing feedback on student questions and assignments, and monitoring their progress. Instructors hold regular video conferences for their assigned courses, providing learners with the opportunity to receive synchronous clarifications on topics. The learner, referred to as "Student," is the third actor and can access, actively participate in, and solve evaluations and assignments.

The interface enables instructors to create and manage courses, modules, related lessons, questionnaire-based assessments, and open-ended questions. In addition, individual assignments are defined. Lessons include theoretical explanations, optional photo/video multimedia materials, and code sequences specific to computer science. The quizzes contain questions with various types of items, displayed randomly, to be solved in a limited time with

a limited number of retakes and with a minimum grade for passing. Students submit their answers to individual assignments by uploading their solutions within a certain timeframe.

The learner has the opportunity to preview the curriculum before enrollment. For approval, the learner can submit a request to join the course. To successfully complete the course, students must adhere to the provided modules, which include studying the theoretical lessons, observing and solving practical examples, and completing self-tests, micro-assignments, and the final evaluation. The general use-case diagram is depicted in Figure 2:



(Source: author's own representation)

Figure 2. Modeling of system requirements using use-case diagram

3. RESEARCH RESULTS

3.1 Comparative study of learning management systems

According to [12], a LMS is a type of technology-based platform that facilitates and coordinates learning processes in the e-learning context. The two main components of these platforms are as follows:

- The server part: manages the essential functions of the platform;
- User interface: specific for different types of users — the administrator and instructor have access to functionalities for managing the platform, while learners, the main beneficiaries of the educational materials, have access to courses, materials, and evaluations.

This type of management system enables instructors to create and publish content, check student engagement, and assess their performance. This also facilitates student interaction via discussions, forums, and video/audio conferencing. To choose a system that can be adapted to the needs of the proposed objectives, a series of LMSs were analyzed, highlighting the features provided by each one. This was done on the basis of the existing documentation of the chosen LMSs, creating a detailed picture of their strengths and limitations. The analysis is presented in Table 1.

Table 1

Comparative analysis of multiple LMSs

Criteria	Moodle	Anthology-Blackboard	Instructure-Canvas	Google-Classroom	Themeum-Tutor LMS	PowerSchool-Schoology Learning	Epignosis-Talent LMS
Type of platform, support, and tools	-Powerful and flexible open source platform; -Active community of users, community support; -Extensibility through plugins from assessment modules to collaboration tools.	-Robust commercial platform; -Commercial support, and a large community of users; -Advanced native tools, but also various plugins.	-Flexible commercial platform; -Extensive commercial support, large community of users; -Easy to customize, plugins to extend functionalities.	-Free platform for G Suite users; -Google/ community support, and online resources; -Close integration into the Google ecosystem and the possibility of adding extensions.	-Accessible commercial platform; -Commercial support, and an active community of users; -Focus on gamification and course management, extension through plugins.	-Complex commercial platform; -Commercial support, and an active community; -Extended functionalities, integration with collaboration tools, and external integrations.	-Flexible commercial platform; -Commercial support, and online resources; -Various ranges of integration and scalability.
User interface – admin, instructor, learner	-Complex interface that requires initial learning for Admin and Instructor; -Easy-to-use interface with quick access to materials for Learners.	-Complex interface that requires adaptation time for Admin and Instructor; -Intuitive interface with quick access to materials for Learners.	-Moderate and intuitive, well-organized interface for Admin and Instructor; -Easy to navigate for learners.	-Simple and friendly interface (especially for Google ecosystem users); -Simple access for all 3 types of users.	-Simple interface, intuitive panel, easy to navigate; -Quick access for all types of users.	-Complex interface, requiring initial preparation for Admin and Instructor; -Intuitive with quick access to courses and materials for students.	-Intuitive and simple interface; -Easy to navigate and customized for all types of users.
Creating, managing, testing, and evaluating courses	-The courses include modules, customizable sections, various activities (forum, lessons, tests), HTML editor; -Student administration, resource management, progress evaluation, setting rights and restrictions; -Tools for testing with various types of items (multiple choice, open questions).	-The courses include modules with multimedia content, interactive tools; -Student administration, monitoring, and evaluation; -Advanced tools for creating tests, tasks, evaluative activities.	-The courses are organized modularly, tools are available for uploading various contents; - Administration of students, management of activities, evaluation and monitoring of progress; -Various testing tools.	-The courses allow easy uploading of documents and multimedia materials based on the G Suite platform; -Student administration, task management, communication and collaboration tools; -Testing and evaluation tools through surveys and rapid feedback.	-The courses allow building on modules, uploading multimedia content, various content management tools; -Testing and evaluation tools, performance reports, gamification.	-The courses allow modules, the incorporation of external content, interaction tools; -Resources management, communication and collaboration tools; -Various testing tools.	-The courses allow modular organization, easy loading of content; -Course administration, student evaluation, progress monitoring; -Various testing and evaluation tools.
Gamification	-Allows the integration of gamification plugins; -Points, badges, competitions.	-Integrates gamification functionalities; -Awards, levels, and competitions.	-Integrate gamification natively or via plugins; -Points, rewards, competitions.	-Limited options.	-Built with a focus on gamification; -Points, rankings, and rewards.	-Native support for gamification; -Competitions and rewards.	-Gamification features; -Options for awards and recognition.
Collaboration, communication, feedback, conferences	-Forum modules; -Feedback, assessment, comment sections;	-Integrated forums; -Feedback and grading;	-Discussions integrated into the course modules;	-Discussions in the courses, comments; -Feedback and rating integrated into	-Student interaction forums; -Feedback, evaluation,	-Discussion and collaboration forums;	-Discussion tools and forums; -Feedback, evaluation, comments;

	-Real-time chat options, private messaging between users; -Integration with external videoconferencing modules (eg. BigBlueButton, Zoom).	-Real-time chat options, notifications; -Integration with videoconferencing platforms (eg. Class Collaborate, Zoom).	-Feedback, grading, evaluation; -Real-time chat options between users, private messaging; -Integration of videoconferencing platforms (eg. BigBlueButton, Zoom).	the G Suite, options for comments and grading; -Integration with Google Meet for video conferencing.	personalized comments; -Public and private chat options between users; -Incorporation of external video conferences in courses (eg. Zoom, Google Meet).	-Feedback, evaluation, comments; -Chat options and private messaging, notifications; -Integration with video conferencing platforms (eg. Zoom, Microsoft Teams).	-Real-time chat options, private messaging, notifications; -Integration with videoconferencing platforms (eg. Zoom, BigBlueButton).
Multimedia support	-Offers support for uploading documents, images, video, and audio, directly in the platform, or linking with external sources.						
Mobility	-Offers support for access from desktop and mobile devices using optimized web platforms.						
Generative AI	-Allows integration through generative AI extensions such as GPT-3.5/4, DALL-E, and Stable Diffusion [13]; -Create personalized dynamic questionnaires, integrate conversational chat, generate images based on text content.	-Offers various generative AI extensions to answer students' questions, help with test and quiz creation, module suggestions, and course-appropriate and copyright-free images [14].	-Does not include built-in generative AI features, but plugins and third-party applications can be used to link with LLM APIs;	-To date, there are no generative AI functions that can be integrated directly into classroom functionalities.	-Integrates generative AI functionality by linking with GPT-3.5/4, but can also integrate third-party plugins; -Can help generate texts for course descriptions, summaries of discussions, or for proposed lessons [15].	-The integration with generative AI is under development for the design of evaluation tools - questionnaires and adaptive testing [16].	-Does not include built-in generative AI features, but plugins and third-party applications can be used to link with LLM APIs.
Costs	-Free software, open source; -Hosting and maintenance costs.	-Costs depending on the number of users/ functionalities.	-Costs per number of users/ institution.	-Free for G Suite users; -Additional options for a fee.	-Costs per number of users; -Costs depending on functionalities and hosting.	-Costs per number of users; -Various options depending on the institution type.	-Costs per user number; -Various options depending on the functionalities.

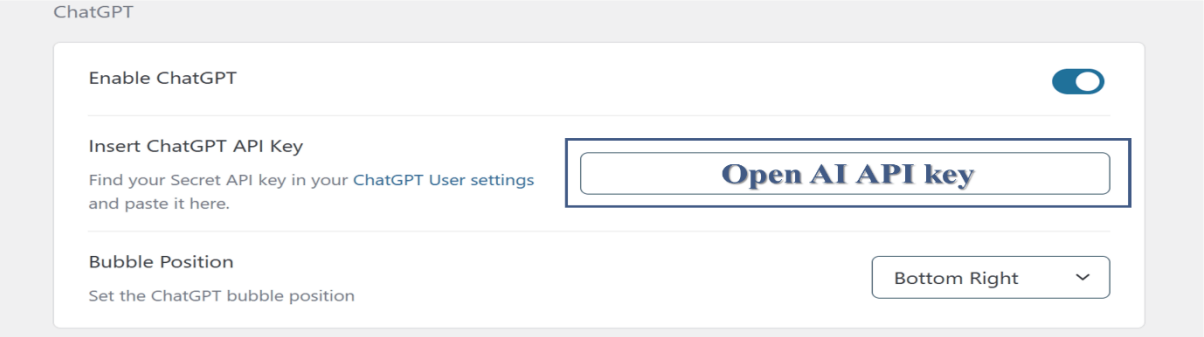
(Source: author's own representation based on information from https://moodle.org, https://instructure.com/canvas, https://classroom.google.com, https://themeum.com/product/tutor-lms, https://talentlms.com, https://powerschool.com/classroom/schoology-learning)

Based on the comparative analysis, Tutor LMS Version 2.3.0 was selected because of its configuration capabilities. Integration with generative AI both natively and through specialized modules and the gamification features makes it suitable for the proposed objectives, conferring most of the necessary functionalities. Even if some functionalities are not natively included, this LMS allows extensions through add-ons. Tutor LMS works as a WordPress (open-source Content Management System - CMS) plugin that also comes with several features for creating and making available interactive lessons to learners. With this plugin, the multiple functionalities of WordPress are complemented by educational functions for creating attractive lessons, quizzes, and educational reports. It is currently among the most popular WordPress-compatible LMS plugins.

3.2 Relevant generative AI features for learning management systems

The ability to integrate generative AI within LMS platforms is an element that nowadays cannot be excluded. It can enhance the quality of teaching materials, reduce the burden of repetitive tasks on instructors, and simplify the process of constructing educational materials by requiring only minimal technical skills. This feature allows instructors to customize learning experiences to suit the needs and learning styles of their students. It can generate supplementary materials for instructors to incorporate into their lessons, generate evaluation questions, and offer automated scoring and feedback [13] .

Specifically, Tutor LMS natively enables the activation of generative AI functionality through integration with the OpenAI API. The system is based on the GPT-3.5/4 language model. It can generate detailed texts with a high level of performance, generate contextual content, and increase the creativity of courses. This feature can be enabled from the administration panel. The connection is easy, being allowed to simply introduce an Open AI API key, as depicted in Figure 3:



(Source: author's own representation)

Figure 3. Connecting the Tutor LMS to the Open AI API

This tool enables easy content creation and facilitates requests based on two inputs: the question and the desired maximum number of words for the response. The answer is generated directly within the text editor of the course/module/lesson. More specifically, text can be generated for course description, topic summary, lesson content, quiz summary, quiz description, assignment summary, and online meeting summaries [15]. This provides additional support for instructors who can build more up-to-date courses using it as an additional source in addition to a scientific bibliography. Instructors should use their critical thinking skills to appreciate the quality of the information returned by this tool. This feature offers them more time to create attractive and creative content that is better adapted to students' needs.

In addition to the Tutor LMS features, third-party plugins can be activated. A comparative analysis presents some of the most relevant plugins, alternatives to native functionality, and adaptable to educational purposes. The analysis is presented in Table 2.

Table 2

Comparative analysis of generative AI tools compatible with Tutor LMS

<table>
<tr><th>Criteria</th><th>Tutor LMS Open AI - native</th><th>WP AI Copilot - plugin</th><th>AI Power - plugin</th><th>AI Content Writing Assistant - plugin</th></tr>
<tr><td rowspan="3">Features</td><td rowspan="3">-Allows the creation of text content;
-Modeling of a request is performed in natural language, providing as input all the characteristics necessary to generate an adequate response.</td><td colspan="2">-Allows the creation of text and image content based on AI;
-Summarize text, create title suggestions, generate ideas, paraphrase, expand an idea starting from the basic one, offer suggestions for introductory or concluding text etc.;</td><td rowspan="2">-It adapts to multiple tasks but develops specific functionalities for marketing, sales, and blogging.</td></tr>
<tr><td colspan="2">-It adapts content generation without limitation to a specific domain.</td></tr>
<tr><td></td><td>-Enables transcription and translation of voice into text;
-Allows the creation of a personalized ChatBot</td></tr>
</table>

			that can be adapted for interaction with students;	
Integrated model	-Open AI GPT-3.5/4; -The integration is performed using the OpenAI API key.	-Customized model selection: GPT-3.5/4, and Davinci; -Integrates image model source: DALL-E;	-Customized text model selection: Open AI GPT-3.5/4, and Azure; -Customized image model source: DALL-E 2/3/HD, Pexels, Pixabay, and Stable Diffusion; -Audio model whisper-1;	-Customized text model selection: Open AI GPT-3.5/4; -Integrates image model source: DALL-E;
		-The integration is performed using specific API key.		
Model customization	-It can be adapted through question-type input and the maximum length of the returned output; -Only text results are returned.	-Selection of language for text generation and writing style/tone; -Set temperature (adapts the model to become more creative), max tokens (limits the output size), top predictions (adapts the diversity of the generated content), frequency/ presence penalty (adapts the frequency/presence of words in the generated text); -Can be generated personalized images with the indicated parameters:		
		searched subject, audience, and number of choice.	image size, style, composites, etc.	
Costs	-Costs generated by using Tutor LMS Pro;	-Free version (with limited functionalities); -Pro version (monthly cost);	-Variants with payment depending on the plugin customization levels;	
	-Costs generated by using Open AI API.			

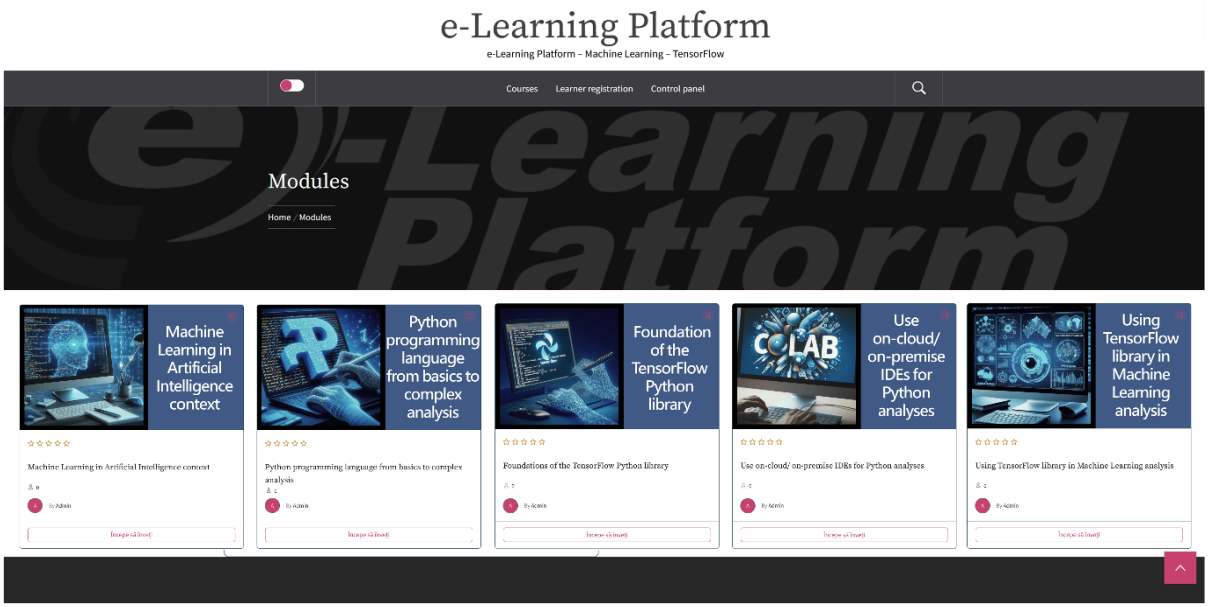
(Source: author's own representation based on information from https://wordpress.org/plugins/ai-co-pilot-for-wp, https://wordpress.org/plugins/gpt3-ai-content-generator, https://wordpress.org/plugins/ai-content-writing-assistant

3.3 System implementation description

Considering the proposed objectives, a system that offers beneficial functionalities for an educational platform with up-to-date capabilities was chosen. The WordPress CMS was installed and configured on a test domain by performing specific steps. Tutor LMS functions as a WordPress plugin. Installation and testing of the plugin were performed for both the free and paid Pro versions. The demonstration is performed using the Pro version, which provides additional functionalities. This LMS was used to develop and incorporate comprehensible educational modules. This is adaptable to various educational levels. Customization of the design was achieved through the configuration of a personalized theme to match the educational purpose. The system allows the definition of a new course with a representative title and description that summarizes the content of the course as clearly as possible. In addition, an image can be specified that graphically symbolizes the course. Various parameters can be set for courses, such as the level of difficulty, the activation of the Q&A section, and the duration of the course. Courses permit the inclusion of different materials – theoretical resources, multimedia materials (images and video clips), evaluative questionnaires, and some requirements and prerequisites (for example, the need for a Google account for accessing the Colab platform). Within a course, modules can be defined, containing lessons, assessments, and assignments.

The platform was tested by creating and uploading a new demonstration course in the field of computer science, more precisely regarding machine learning in the context of AI. The construction of the curriculum for this course was based on the research of a selective bibliography on the subject, as well as using the integrated generative AI functionalities. This feature was used to offer suggestions regarding the structure of the modules and lessons. Five modules were built, each with associated specific lessons, evaluations, and assignments. The last module is predominantly applicative, bringing together information from the entire course. The technologies addressed in this study are topical and are less frequently addressed in dedicated interactive courses. The five newly developed modules are as follows and are integrated into the platform, as shown in Figure 4.

1. Introduction to Machine Learning in the context of Artificial Intelligence;
2. Python programming language from the basics to complex analysis;
3. Foundations of the TensorFlow Python library;
4. Use of on-cloud/ on-premise IDEs for Python analyses;
5. Using the TensorFlow library for machine learning analysis (for regression and classification problems; application on established datasets).



(Source: author's own representation – course images are generated with DALL-E)

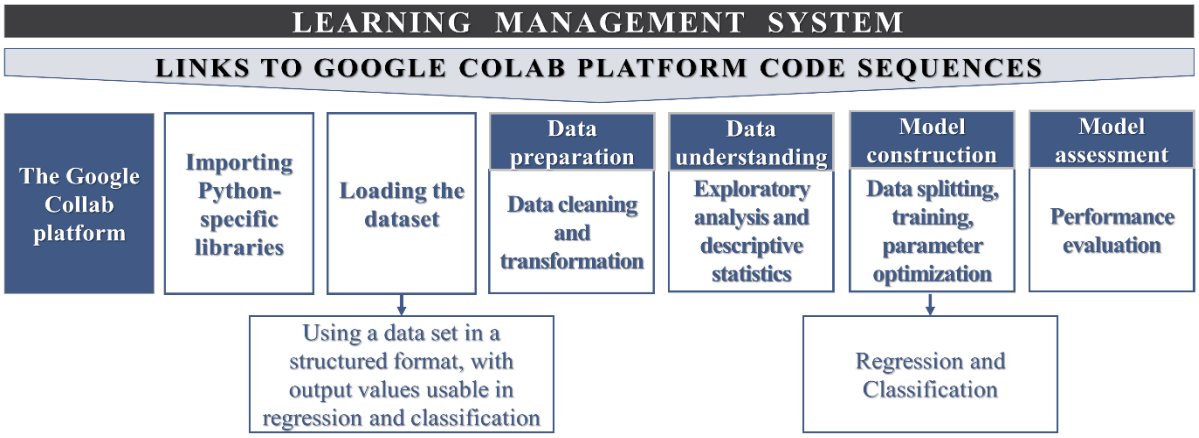
Figure 4. Screenshot from the learner interface: presentation of the modules

Briefly, the content of the course modules is as follows:

- *Module 1* elaborates on the concept of AI, which, in a broad sense, represents any technology designed to imitate and function like a human. A subfield of AI is considered ML, a technology capable of analyzing a large amount of data and information that is continuously generated and can be managed to make predictions and decisions. The first proposed module highlights theoretical notions regarding ML algorithms and techniques. The field of ML can be divided, depending on the problems that can be addressed, into supervised, unsupervised, semi-supervised, and reinforcement learning. In this module, the first two categories are detailed together with the types of tasks in which they can be used. Supervised learning is typically employed to address two main tasks: regression and classification. One of the main tasks of unsupervised learning is clustering, which plays a significant role in detecting patterns and structures within uncategorized datasets [17]. The advantages and disadvantages of both categories are highlighted.
- *Module 2* is dedicated to Python, which is a powerful and versatile programming language that is widely used. It finds applicability in various domains, including software development and web applications, as well as for AI and ML analysis. The fundamental aspects of this language are detailed, including variables, data types, structures, and specialized libraries for descriptive statistics. Libraries dedicated to data preprocessing and those introductory to data analysis and automatic learning are also described.
- *Module 3* introduces an open-source symbolic mathematics software library called TensorFlow, which is used for ML applications [18]. The popularity of TensorFlow is

due to several concepts on which it is based. This module highlights TensorFlow-related aspects such as computational graph concept, the adaptability of the API structure for multiple programming languages, including Python, and the distributed work that is easy to implement regarding complex tasks. For ML tasks, TensorFlow provides pre-implemented frameworks and algorithms that can be applied to large datasets, achieving outstanding accuracy and performance. TensorFlow's popularity is largely due to its open-source library, which allows analysts to easily extend compatibility by adding functions and support for different formats and datasets. An essential feature of this technology is that it enables the construction and training of powerful models without compromising performance or running speed [19].

- *Module 4* presents different on-cloud and on-premise IDEs through comparative analysis. Emphasis is placed on Jupyter Notebook, which is generally run locally as an on-premise web solution, and Google Colab, which is a cloud-based solution. Google Colab is considered as an improved version of the Jupyter Notebook. It is a free environment that runs entirely in the cloud and is useful for building ML models without requiring special configuration or computational resources. This provides access to GPU/TPU resources. It enables writing and execution of Python scripts, creating, uploading, and sharing notebooks, free cloud storage, importation of external datasets, and integration of useful AI analysis libraries. It is suitable for use within the course without requiring special configurations from the students.
- *Module 5* develops a practical experimental task using the Python programming language and the TensorFlow library for various ML analyses. The flow developed within the module is depicted in Figure 5. The web IDE Google Colab is used to run the code sequences, allowing the construction of shareable scripts, which are useful in the online learning process. These analyses consider the integration of the TensorFlow library for both regression and classification.



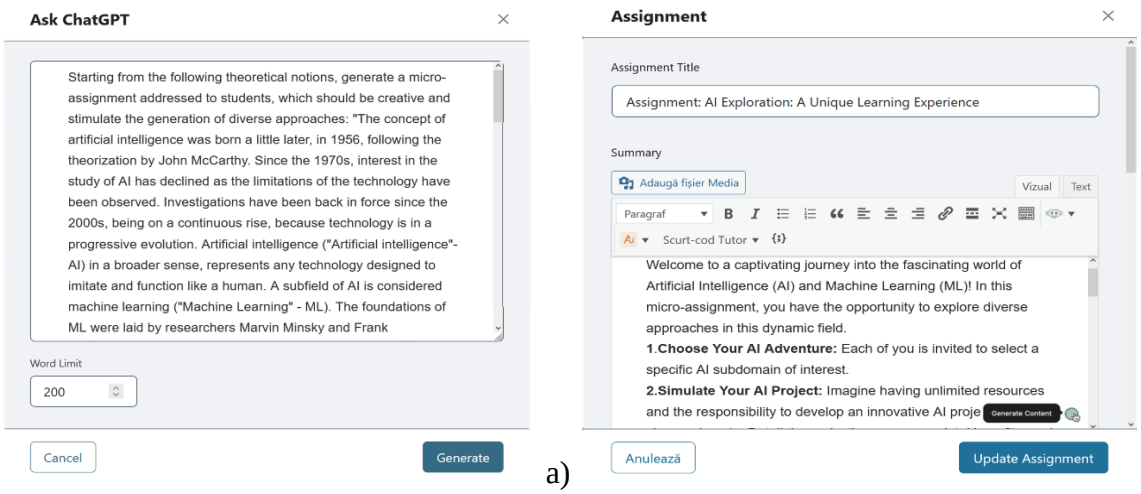
(Source: author's own representation)

Figure 5. Machine Learning Supervised Learning analysis workflow applied in Module5

This module presents steps for importing specific libraries that are useful for ML analysis. The practical exercises are performed on established datasets from the UCI Machine Learning Repository; this source exposes data that are labeled according to the analyses for which they can be applied. The data are passed through a complex process of understanding and cleaning. This process involves removing missing values and outliers. ML models are then built using the TensorFlow algorithm, applied to the training set, and the performance obtained in the predictions generated on the test set is tracked. Each step of the analysis combines the practical

elements with the scoring of some theoretical aspects so that the students can master them as easily as possible. The analysis is performed for two specific problems of supervised ML, more precisely Regression and Classification. In the case of the regression problem, the model's performance is determined by tracking some coefficients, such as the mean squared error, the square root of the mean squared error, and the coefficient of determination. In the case of classification, the model's performance is evaluated using specific metrics such as accuracy, precision, and sensitivity.

Theoretical and practical modules were uploaded to the platform, improving through elements made available by the LMS. The native generative AI Tutor LMS functionality was activated by connecting with the administrator credentials. Thus, access is offered to all instructors who connect to the platform, ensuring them the possibility of generating text content within the courses. This functionality was directly used in the developed lessons for various tasks. More precisely, by entering as input in the generative AI prompt text sequences from the theoretical part of the lessons, based on a specialized bibliography, micro-assignments were generated. The request is addressed in the form: "*Starting from the following theoretical notions (...), generate a micro-assignment addressed to students, which should be creative and stimulate the generation of diverse approaches.*" by fitting in a maximum number of "*200 characters*". Such a task is presented in Figures 6 (a) - task input and (b) - result:

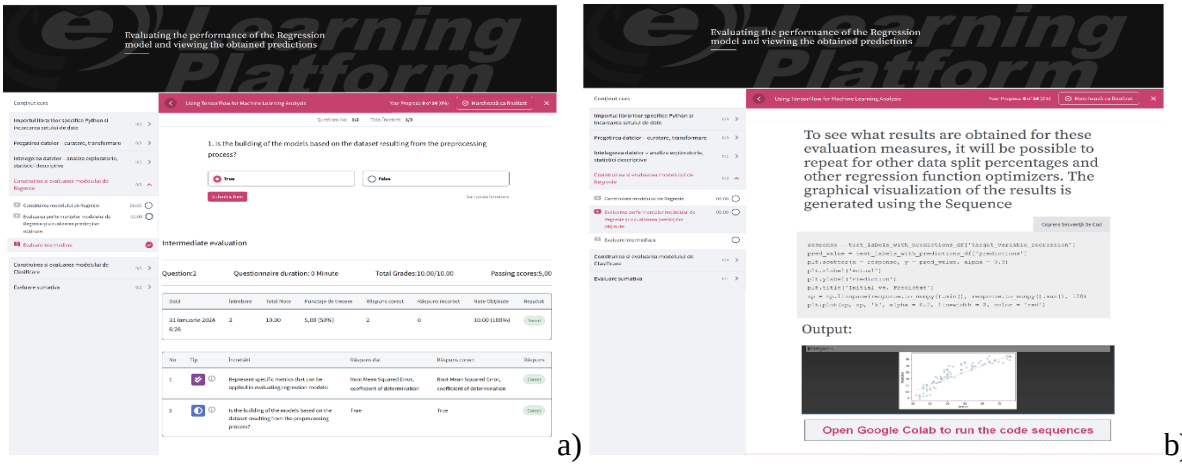


a) b)

(Source: author's own representation)

Figure 6. Screenshot from the tutor interface: a) assessment design using native generative AI request, b) the resulting assignment

At the end of each lesson, intermediate evaluations are included. At the end of each module, a summative evaluation is included. Evaluative tools are designed in the form of quizzes and questions with open answers to highlight students' creativity. Customized requests were made to generate questions with different types of items using the generative AI feature. Such a questionnaire is presented in Figure 7 (a); the lesson based on which the questionnaire was designed is presented in Figure 7 (b). The command in the prompt was made of the type "*Using the following text sequence (...), make a multiple choice/single choice question with 5 answers*". The prompt returned suggestions that, with small additions and reformulations, were successfully used in the evaluation stages. The integration of this feature for quiz development represents a valuable facility, the questions and answers suggestions being developed in the spirit of the information presented in the theoretical materials.

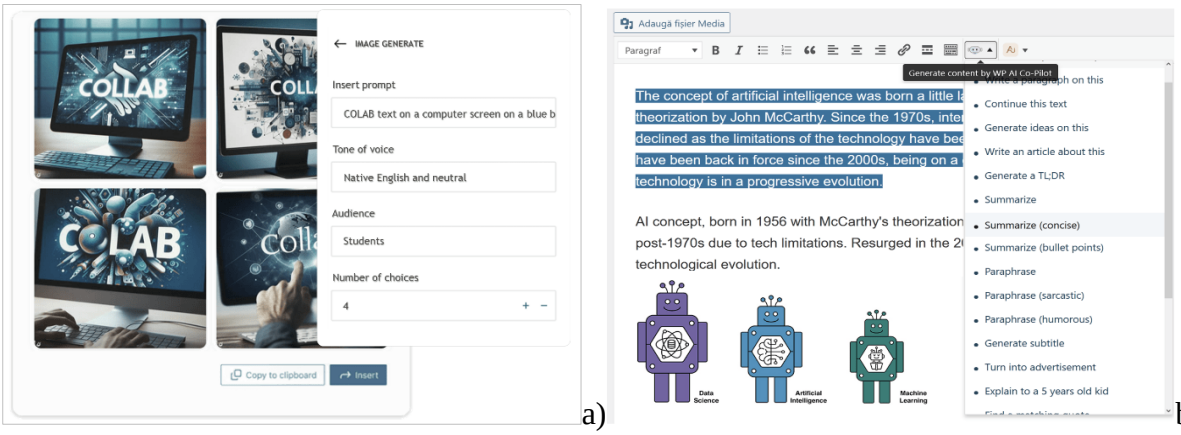


a) b)

(Source: author's own representation)

Figure 7. Screenshot from the learner interface: a) intermediate evaluative quiz created with generative AI suggestions, b) presentation of a lesson containing code sequences

The ability to work on Wordpress support also came with a series of other generative AI functionalities independent of Tutor LMS. Thus, various third-party modules were activated to enhance the courses with attractive elements. For example, were used the "WP AI CoPilot" plugin which integrates text generation functions based on the large Open AI GPT-3.5/4 language models and DALL-E image model. This plugin is visible in the text editors at the level of lessons/quizzes/assignments. Using this tool, the lessons received suggestive auto-generated images that symbolically reflect the theoretical and applicative content. The request for an image is made according to the model shown in Figure 8 (a). The WP AI CoPilot plugin can also be used for text generation, working in a simplified way compared to the native integrated functionality. It has multiple default functions applicable to the text, such as generating suggestions for the text continuation, summarizing, and paraphrasing. Within the effective content of the lessons, minimally generative functionalities were used, especially to reformulate certain ideas to make them more accessible to the students, capitalizing on the content from bibliographic sources. The request for text summarization can be done as shown in Figure 8 (b).



a) b)

(Source: author's own representation)

Figure 8. Screenshot from the tutor interface: a) generating a suggestive image for the Google Colab chapter, b) generating text summarization using WP AI CoPilot

All these facilities support the instructors, who experience a way of working adapted to the century in which we live, allowing them to reduce the time allocated for certain tasks, being

able to develop more the creative part and the pursuit of the most up-to-date sources of information to integrate into the development most relevant courses. The result of the research consists of a solution developed after the pandemic period, existing the premise of increasing the use of technology in education and the democratization of AI through the emergence of generative models that can be integrated as support for learning at the academic level. The proposed solution stands out for its adaptability and flexibility, allowing it to be used in various contexts and by different groups of users. Although the solution was implemented in a test environment, it is anticipated that it can contribute to the improvement of educational practices, offering valuable opportunities through replication and use in real learning environments.

4. CONCLUSIONS

The pandemic has revealed that education systems can show resilience by adapting to rapid changes and adopting innovative solutions to continue the educational process. These solutions must continue to be used and improved in post-pandemic times to foster a more flexible and dynamic learning environment. Embracing technology, online platforms, and hybrid learning models not only enhances accessibility but also prepares education systems to effectively navigate future challenges. LMSs are a good example of modern solutions that can be successfully used for e-learning purposes. These can combine both synchronous and asynchronous interactions and integrate the necessary elements in the teaching–learning–evaluation process.

In this study, Tutor LMS was implemented, which integrates various features that enhance the interactivity and presentation of the lessons. This system was selected following a comparative analysis. One of the most important features that were the basis of the choice represented the possibility of native integration with a generative AI API and specialized plugins. Testing of the system demonstrated its full functionality, with an intuitive interface that supports customization and adaptation for the proposed discipline, as well as the potential for expansion to other disciplines and study levels. The developed curriculum was enabled to proceed through the flow determined in the modeling stage. For the platform, the necessary modules were activated and extended through add-ons and customized functions. Thus, functionalities ranging from system configuration to user management and the creation of a course with five study modules were tested. Within the modules, interactive lessons were designed that presented theoretical and practical notions, multimedia materials, and code sequences. Evaluative quizzes and individual assessments were established throughout the courses, defining the minimum criteria for scoring and the deadlines to submit solutions. In designing the course materials, a well-documented bibliography was used in conjunction with generative AI tools to enhance and diversify the proposed lessons.

The proposed solutions have certain limitations. The AI's generative function is not always accurate and sometimes hallucinates, thus requiring the instructor's critical thinking for successful results. Using the Open AI API generates some costs, depending on the amount of requests. AI technology could be otherwise harmful if a safe, human-led, responsible, and ethical approach is not promoted [20]. The implementation of an LMS requires some technical knowledge and involves costs, from hosting to the cost of specific plugins and subscriptions, depending on the level of development.

REFERENCES (TRANSLATED AND TRANSLITERATED)

[1] D.-C. Arghir, "The Impact on Community Mobility during the Pandemic Crisis in Romania," in *Proceedings of the 37th International Business Information Management Association Conference*, Cordoba, 2021. (in English)

[2] J. Rigby and B. Satija, "WHO declares end to COVID global health emergency," Reuters, 8 05 2023. [Online]. Available: https://www.reuters.com/business/healthcare-pharmaceuticals/covid-is-no-longer-global-health-emergency-who-2023-05-05. Accessed: 1.10.2023. (in English)

[3] R. Salhab, S. Hashaykeh, A. Rabo, Z. Khlaif, S. Salha and S. Affouneh, "Best Practices of School Teachers to Sustain Their Students Learning During Crisis," *Journal of Southwest Jiaotong University*, vol. 56, no. 4, pp. 44-57, 2021, doi: https://doi.org/10.35741/issn.0258-2724.56.4.6. (in English)

[4] S. Thakkar and H. Joshi, "E-Learning Systems: A Review," in *2015 IEEE Seventh International Conference on Technology for Education*, Warangal, 2015, doi: https://doi.org/10.1109/T4E.2015.6. (in English)

[5] B. Giesbers, B. Rienties, D. Tempelaar and W. Gijselaers, "A dynamic analysis of the interplay between asynchronous and synchronous communication in online learning: The impact of motivation," *Journal of Computer Assisted Learning*, vol. 30, no. 1, pp. 30-50, 2014, doi: https://doi.org/10.1111/jcal.12020. (in English)

[6] O. O. Ayotunde, D. I. Jamil and N. Cavus, "The Impact of Artificial Intelligence in Foreign Language Learning using Learning Management Systems: A Systematic Literature Review," *Information Technologies and Learning Tools*, vol. 95, no. 3, pp. 215-228, 2023. doi: https://doi.org/10.33407/itlt.v95i3.5233. (in English)

[7] V. M. Bradley, "Learning Management System (LMS) Use with Online Instruction," *International Journal of Technology in Education*, vol. 4, no. 1, pp. 68-92, 2021, doi: https://doi.org/10.46328/ijte.36. (in English)

[8] J. M. Namada, "Learning Management Systems in the Era of E-Learning," in *Machine Learning Approaches for Improvising Modern Learning Systems*, IGI Global, 2021, pp. 169-190, doi: https://doi.org/10.4018/978-1-7998-5009-0.ch007. (in English)

[9] U. Alturki and A. Aldraiweesh, "Application of Learning Management System (LMS) during the COVID-19 Pandemic: A Sustainable Acceptance Model of the Expansion Technology Approach," *Sustainability*, vol. 13, p. https://doi.org/10.3390/su131910991, 2021, doi: https://doi.org/10.3390/su131910991. (in English)

[10] M. Fırat, "Integrating AI Applications into Learning Management Systems to Enhance e-Learning," *Technology and Lifelong Learning*, vol. 4, no. 1, pp. 1-14, 2023, doi: https://doi.org/10.52911/itall.1244453. (in English)

[11] K. Naidu and K. Sevnarayan, "ChatGPT: An ever-increasing encroachment of artificial intelligence in online assessment in distance education," *Online Journal of Communication and Media Technologies,*, vol. 13, no. 3, 2023. doi: https://doi.org/10.30935/ojcmt/13291. (in English)

[12] P. Kirvan and B. Kate, "Learning Management System (LMS)," TechTarget, 2020. [Online]. Available: https://www.techtarget.com/searchcio/definition/learning-management-system. Accessed: 05.05.2022. (in English)

[13] A. Fry , "The potential of AI and Moodle," Moodle, 08 09 2023. [Online]. Available: https://moodle.com/news/the-potential-of-ai-and-moodle. Accessed: 14.10.2023. (in English)

[14] Anthology Advancing Knowledge, "Empower Instructors with AI," Anthology, 1 11 2023. [Online]. Available: https://www.anthology.com/sites/default/files/2023-11/Anthology-AI%20Design%20Assistant-Overview-Bizgov-V1_11-23.pdf. Accessed: 14.10.2023. (in English)

[15] S. Asif, "Tutor LMS v2.1.8: Introducing ChatGPT Integration For Next-Level Content Generation," Themeum, 01 03 2023. [Online]. Available: https://www.themeum.com/tutor-lms-v2-1-8. Accessed: 15.10.2023. (in English)

[16] CXOtoday News Desk, "Powering the Future of Education in India: A Deep Dive into PowerSchool's Ambitious Expansion, Innovative Solutions, and Tech-Enabled Interventions," Trivone, 10 11 2023. [Online]. Available: https://www.cxotoday.com/interviews/powering-the-future-of-education-in-india-a-deep-dive-into-powerschools-ambitious-expansion-innovative-solutions-and-tech-enabled-interventions. Accessed: 16.10.2023. (in English)

[17] M. Sanatan, "Unsupervised Learning and Data Clustering," 20 05 2017. [Online]. Available: https://towardsdatascience.com/unsupervised-learning-and-data-clustering-eeecb78b422a. Accessed: 25.10.2023. (in English)

[18] Geeks for geeks, "Introduction to Tensor with Tensorflow," Sanchhaya Education Private Limited, 2020. [Online]. Available: https://www.geeksforgeeks.org/introduction-tensor-tensorflow. Accessed: 06.05.2022. (in English)
[19] TensorFlow, "Why TensorFlow," Google, 2022. [Online]. Available: https://www.tensorflow.org/about. Accessed: 29.10.2023. (in English)
[20] H. Gasvoda, "Navigating Generative AI: Key Insights for This School Year," Instructure, 29 9 2023. [Online]. Available: https://www.instructure.com/resources/blog/navigating-generative-ai-key-insights-school-year. Accessed: 05.11.2023. (in English)

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УПРОВАДЖЕННЯ СИСТЕМ УПРАВЛІННЯ НАВЧАННЯМ З ФУНКЦІЯМИ ГЕНЕРАТИВНОГО ШТУЧНОГО ІНТЕЛЕКТУ В УМОВАХ ПОСТ-ПАНДЕМІЇ

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Анотація. В останні роки глобальна система освіти зазнала трансформаційних змін, усе частіше використовуючи онлайн-інструменти в навчанні у відповідь на виклики сучасного життя, зокрема епідеміологічні ситуації. Це дослідження має на меті представити систему управління навчанням (LMS), призначену для підвищення рівня надання освітнього контенту, сприяння навчанню та розвитку студентів у динамічному та адаптивному навчальному середовищі, що відповідає потребам сучасного розумного життя в містах, а саме необхідністю зв'язку та синхронізації. Система пропонує інтеграцію моделі генерації мови з доступом до інтерфейсу прикладного програмування (API). Такий підхід не лише спрощує підтримку викладачів, але й полегшує створення курсів з використанням адаптованої та послідовної мови. Система виходить за межі традиційних функцій LMS, надаючи пропозиції щодо вдосконалення та урізноманітнення уроків. Завдяки своїй гнучкості та адаптивності запропонована LMS задовольняє різні рівні підготовки учнів у різних сферах. Таке рішення було прийнято після проведення порівняльного аналізу різних платформ на основі функціональності, інтуїтивно зрозумілої презентації та можливостей кастомізації. Обрана система виявилась найбільш прийнятною для розробки та доставки освітнього контенту. Щоб продемонструвати ефективність системи, було розроблено навчальну програму для спеціалізованої галузі знань - штучного інтелекту (ШІ), з особливим акцентом на практичному застосуванні алгоритмів машинного навчання. Ця програма містить теоретичні та практичні прикладні компоненти, доповнені набором інструментів оцінювання та завдань, адаптованих до запропонованої тематики. Уроки в межах цієї навчальної програми були розроблені на основі інформації з різних бібліографічних джерел. Особливістю цієї системи є інтеграція функцій генеративного штучного інтелекту безпосередньо в LMS, що збагачує процес викладання, навчання та оцінювання.

Ключові слова: онлайн-навчання; система управління навчанням; генеративний штучний інтелект; COVID-19.